

LANDSCAPE + SKY:  
LAND USE ANALYSIS AT THE SCALE OF FLIGHT

BY

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THESIS

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## ABSTRACT

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This thesis proposes a method for recognizing land use trends and ecological resources relevant to bird migration and endangered species conservation efforts. From the scale and perspective of avian flight, and through my experience as a pilot, I demonstrate how the sequence of flight can create a model for understanding the relationship between land use and ecological habitat by using the flight scale of birds and aircraft.

With population growth and continuing development, wildlife and natural habitats are being reduced. It is crucial to seek new ways of comprehending the impacts of development. By analyzing land use at the scale of flight or at a “bird’s eye view,” land use developers and landscape design practitioners may have a unique opportunity to understand the impacts of land use planning decisions on migration and avian populations.

My thesis analyzes land use in a sequence along a planned flight route in regards to ecological conservation for migratory bird species. Land use is often analyzed and planned at urban settings at relatively small scales. Land use analysis at the scale of flight demands pattern recognition and understanding at a much larger scale and from a different visual perspective. Airborne travel, both for birds and man-made mechanisms, is a dynamic system requiring prior planning or support systems, constant alertness, and the need to recognize certain landmarks and conditions along a linear path or corridor.

This thesis uses maps, charts, drawings and other spatial representations to interpret information from ornithology, aviation, and ecology for making landscape planning decisions on

the ground. It explores a 3-dimensional land use analysis by combining vertical and ground based information. Conclusions will show that land conservation and planning endeavors should not strictly be analyzed from the ground, but attention to ecological systems and land use management should also be extended to the scale and parameters of flight.

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## CHAPTER 1: INTRODUCTION

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Throughout history there have been five waves of species extinction, some of which were caused by natural processes such as volcanism, asteroid impact and plate tectonics. However, it has been suggested that we are currently in the sixth wave of extinction phenomenon in which humans are almost entirely to blame (Hughes, 9). In general, human development is swiftly generating negative impacts on non-human life forms, such as habitat loss, overexploitation, pollution, and invasion of exotic species. Though the definition of land use refers to humans activity, to sustain a healthy environment for all beings the definition and application of land use should be extended to all species. Efforts are growing to help support green infrastructures, sustainability, and creating healthier habitats for wildlife and humans, but is land use being analyzed at an appropriate scale?

An area of landscape architecture that should be explored in more detail is that of the vertical and 3-dimensional landscape with an ecological perspective. As the world population has grown, land has become more valuable and structures tend to reach skyward for more efficient development. However, our atmosphere is like layers on a cake, different altitudes produce different conditions. The higher in the sky most living creatures approach, the more sensitive and harmful the conditions may become without taking the appropriate precautions. Understanding land use at the scale of flight, and from an avian perspective will create an opportunity for more mindful conservation land use planning.

The avian species chosen as my research subject is a large migratory bird called the whooping crane. This bird is currently under the endangered species watch list with human activities and development being the primary reasons for its former decline. The first part of this

thesis will be a discussion of land use history and issues on the ground. The next portion will transition to the ground/ sky relationship by introduce the whooping crane, and finally the vertical and 3-dimensional landscape will be addressed.

## CHAPTER 2: LAND USE

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Land use is defined as the management and modification of the natural environment into a built environment. It is the human use of land that typically transforms wilderness for agriculture, industry, residential and recreational development, or other purposes. This is at odds with the definition of natural, which is an environment not made or caused by humankind. Many non-human species need a natural environment, or one that is similar to an undisturbed environment, to function and thrive. The majority of our current environment has been completely altered by man, forcing the other 2 million non-human species on this planet to adapt quickly to survive or disappear into extinction in our quickly developing world. With research surfacing about the heavy decline of non-human species, a more thorough land use analysis will need to play a major role in preserving resources and creating new habitat.

Land use is often analyzed at localized, specific scales. Land use at the scale of flight observes larger tracts of land and their connections with other land uses, adding a new dimension to land use through 3D analysis. The American landscape has been exploited in the Midwest, progressively causing sustainability issues for both humans and non-humans. With better understanding of our historical land use and current practices at a different scale, an opportunity for new land use analysis can be created.

## HISTORY

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The selected regional site for this study is approximately 300 miles long across Illinois and Wisconsin (Figure 1). This area is at the heart of the Midwestern Corn Belt and agricultural grain history. Illinois has transformed into a landscape of primarily agricultural land (Figure 2) while Wisconsin provides slightly more varied terrain and ecological biodiversity. Economic, technological, and social trends have had major influences over Illinois' changing landscape. Before heavy development took place across Illinois, tall grass prairies covered 21.6 million acres (61%) of the 35.6 million acres of total land area in the state while forests covered almost 14 million acres (38% land cover) (Bretthauer, 2003). Specifically, most native prairielands were converted to agricultural use during the early to mid-1800s due to the invention and convenience of the steel plow (Connor & Hartel, 2001).



FIGURE 1. SELECTED SITE REGION ACROSS ILLINOIS AND WISCONSIN



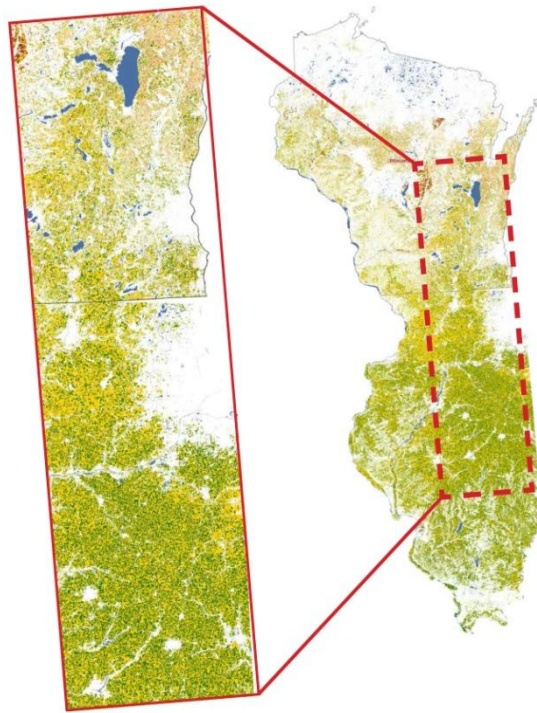


FIGURE 2. CROPLAND DATA 2012

Illinois is rated among the top six states with the highest wetland percentage lost. In general, America has lost over half of its original wetlands. Before early settlement, it was estimated that Illinois had 9,412,659 acres of wetlands, but “the most recent inventory of wetlands in Illinois reveals that approximately 917,765 acres of natural wetlands remain, of which only 5,000 acres are undisturbed” (Baum, 1996). Original wetland acreage in Illinois has dropped over 90% since settlement of the United States, completely altering the natural landscape of Illinois and several other states. The amount of natural prairies, forests, and wetlands has decreased immensely within the last two hundred years and are largely human-driven occurrences (Figure 3).

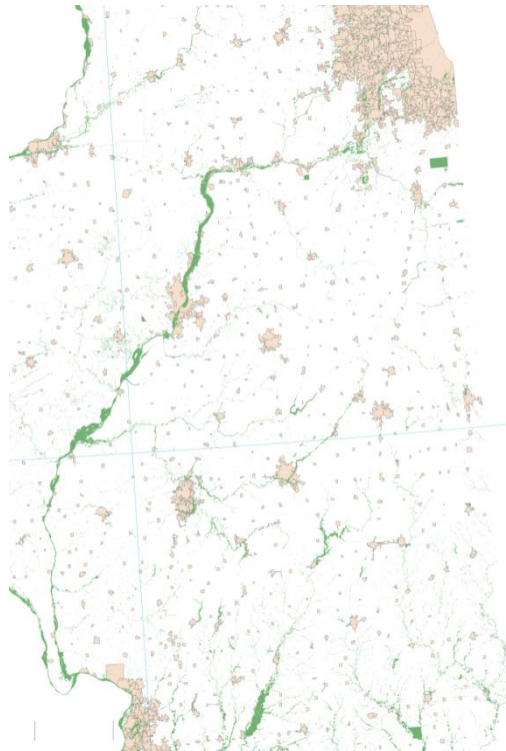


FIGURE 3. LAND USE IN NORTHERN ILLINOIS: URBAN LIMITS (PINK), WETLAND OR FOREST (GREEN), AGRICULTURE (WHITE)

Pollution and habitat destruction are becoming major issues to our non-human populations. According to the Critical Trends Assessment Program (CTAP) report in 2001, Illinois streams have fair to poor habitat quality and species diversity and some species in particular have experienced drastic range losses across the because of human disturbances (Critical Trends Assessment Program: 2001 Report, 2002). Particularly, avian species population depletion will be discussed in Chapter 3.

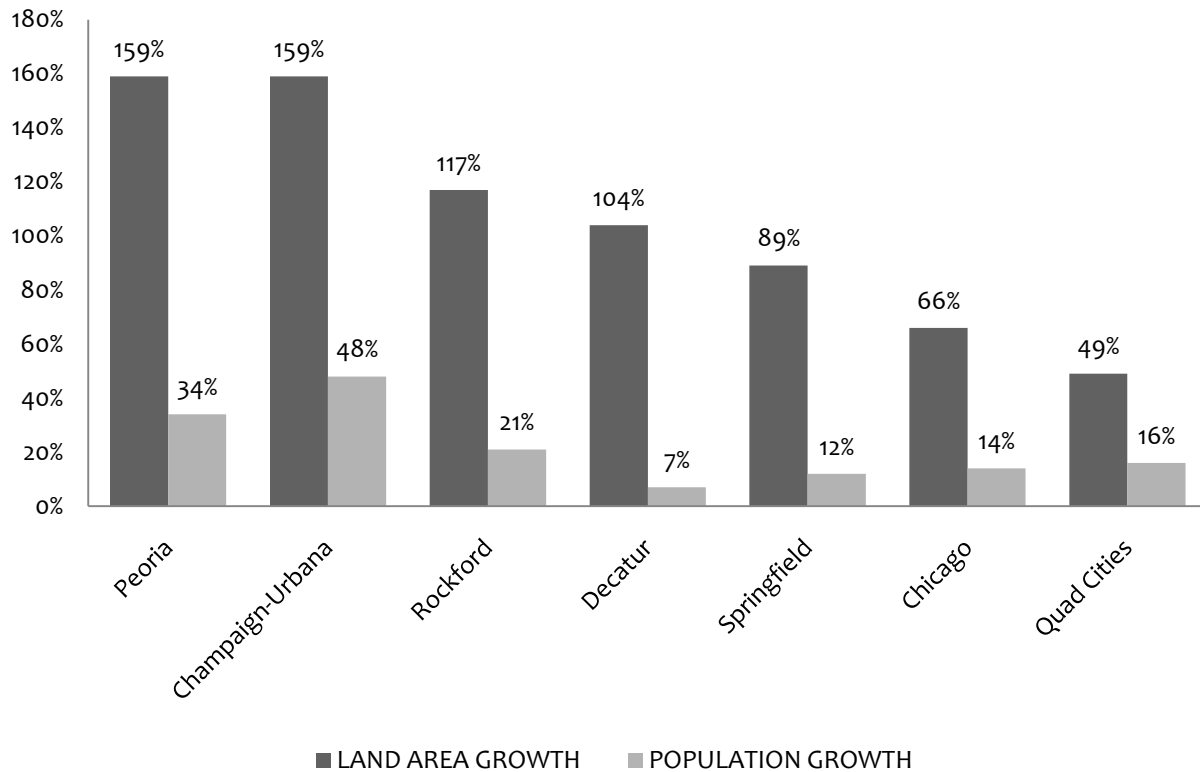


TABLE 1. POPULATION, LAND AREA GROWTH IN ILLINOIS METRO AREAS  
(CONNOR & HARTEL, 2003)

Table 1 addresses the issue of land area growth emerging faster than the human population. The U.S. Census Bureau surveyed 70 cities in America with findings estimating that on average, fifteen percent of a city's land containing only residential structures was deemed vacant (Pagano & Bowman, 2000). Residential areas occupy only a certain portion of metropolitan landscapes. This insinuates that commercial and industrial vacancies were not surveyed and greater percentages of these metropolitan areas are vacant. Though we have significant percentages of vacancy in already established cities, we still extend out land use development into natural areas to supply human needs. Seven cities in Illinois surveyed saw land area growth at least triple the population growth of the specific city (Table 1). Because we are

quickly developing land resources for both humans and non-humans, the definition of land use should be extended to non-human species to help support healthier infrastructures for all species.

## FRAGMENTATION

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Fragmentation is defined as the breaking up of a larger, intact habitat into smaller dispersed patches. A common landscape pattern is fragmentation, which is often associated with the loss and isolation of habitat (Dramstad, 41). Dramstad also suggests that “only by recognizing and addressing landscape changes across different scales (perhaps at least three) can planners and designers maximize protection of biodiversity and natural process” (Dramstad, 41). Perception of habitat can often change as land use scales increase or decrease. One of the observed scales to help address fragmentation should be land use at the scale of flight to help better understand the resource networks available for migratory non-humans. With that, this additional 3-dimensional scale could provide new insight.

To address fragmentation in the landscape in general, I observed land use in the Champaign-Urbana area, particularly spaces with potential for providing wildlife habitat in parks. While parks in urban settings are intended for humans, some of their benefits include providing habitat for wildlife and insects. With that in mind, I then evaluated the quality of the space with criteria derived from ecological principles. Some criteria include closeness to roadways, visibility of residences, frequency of traffic or pedestrians, and etc. Figure 4 identifies parks at this scale as pixilated segments with low connectivity to other parks in the landscape as a whole. This can cause issues for wildlife to avoid busy roadways and safely travel from one place to another.

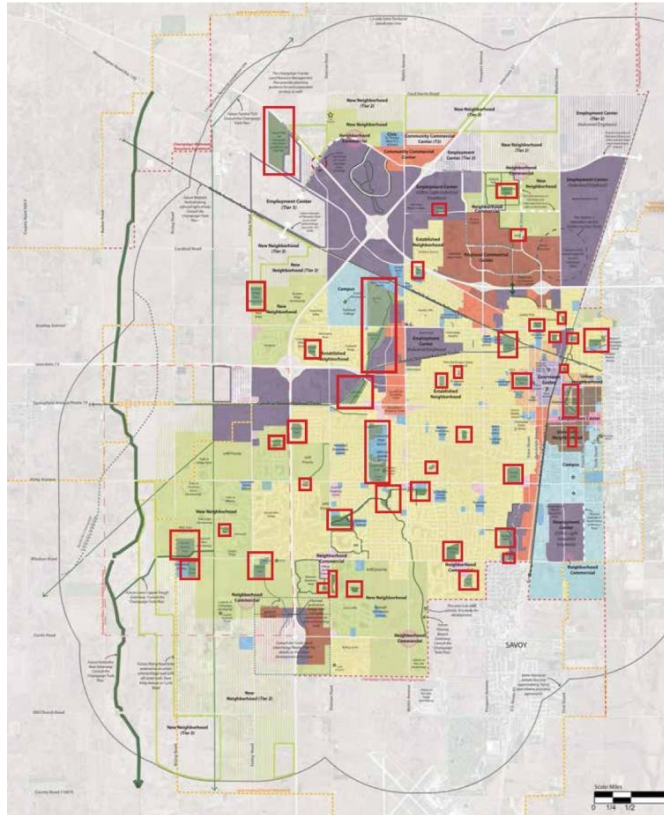


FIGURE 4. IDENTIFIED PUBLIC PARKS IN CHAMPAIGN-URBANA

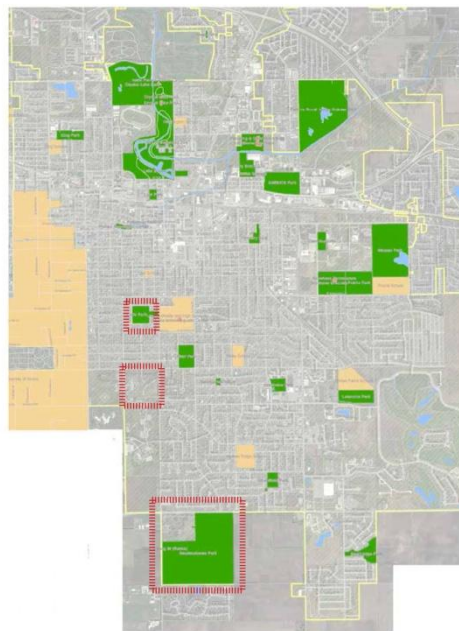


FIGURE 5. CARLE PARK, ORCHARD DOWNS, AND MEADOWBROOK PARK MARKED IN RED

Overall, Meadowbrook Park was the most ecologically sensitive design compared to Carle Park and Orchard Downs. Not only is this one of the largest parks, but prairie plantings are located a great distance from the busy roadway, and trees help buffer sounds and views of residential complexes (Figure 6). Pedestrian paths are placed around the periphery allowing for most wildlife to remain undisturbed.



FIGURE 6. MEADOWBROOK PARK - ECOLOGICALLY SENSITIVE LANDSCAPE WITH MORE OPPORTUNITY FOR HABITAT AND RESOURCES



FIGURE 7. CARLE PARK - TYPICAL PARK WITH LITTLE “HUMAN-ACCEPTED” HABITAT FOR LARGER ANIMALS

Analyzing at land use at the urban scale can help us see how fragmented green spaces are from one another and how corridors are nonexistent (Figure 4 and Figure 5). This is not to say that parks are a negative contribution, they are much better than completely paved surfaces, but



there is much more to consider if we are ever going to transform these places into habitat for more than humans.

## VERTICAL ELEMENTS

An issue with studying land use on a base map is that the vertical elements in our 3-dimensional world often become transparent. However, one example of a base map that helps illustrate the vertical landscape is an aeronautical sectional chart (Figure 8). Pilots are taught to read and interpret symbols on a flat map that are protruding into the sky. Vertical obstacles that would be important to note in land use planning would be power lines, wind turbines, buildings, and cell phone towers. The development of these vertical obstacles affects both humans and non-humans.

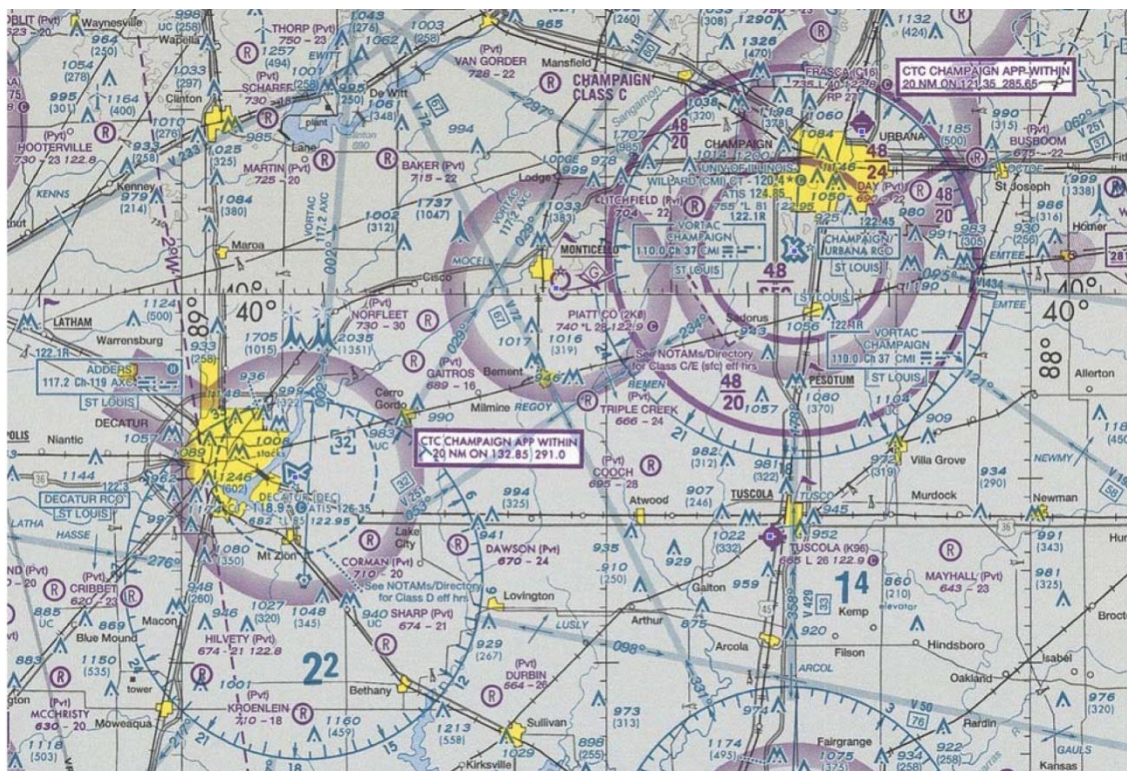


FIGURE 8. DETAILED VERSION OF AN AERONAUTICAL SECTIONAL CHART

With widespread popularity of modern technology (e.g. smart phones), communication towers are increasing across the nation. While many of these technological resources are immediately beneficial to humans, towers can pose deadly threats to migratory birds. According to the United States Fish and Wildlife service, communication towers kill approximately 7 million birds each year (Bird Collisions at Communication Towers, 2013). Flashing lights and beacons on top of towers can sometimes confusing traveling birds causing them to become disoriented, eventually leading to death by exhaustion or collision with the tower and wires.

However, buildings have been known to kill billions of birds in North America each year. According to the Fatal Light Awareness Program (FLAP), an estimated 1.5 - 2 billion migratory birds are killed across North America as a direct result of human activity each year (FLAP, 2014). Sprawling developments create new obstacles for wildlife and make survival or migration efforts more complicated. Metropolitan areas occupy large tracts of land with very little availability of natural resources.

The Audubon Society has compiled data from the last 40 years finding that the average population of common bird species in the steepest decline have fallen 70%, from 17.6 million to 5.35 million birds (Butcher, 2007). The information from the Audubon Society only includes 10 common bird species that are vanishing; this data does not include thousands of other avian species including migrants.



## Human Causes of Bird Deaths in the United States and Canada (each year)

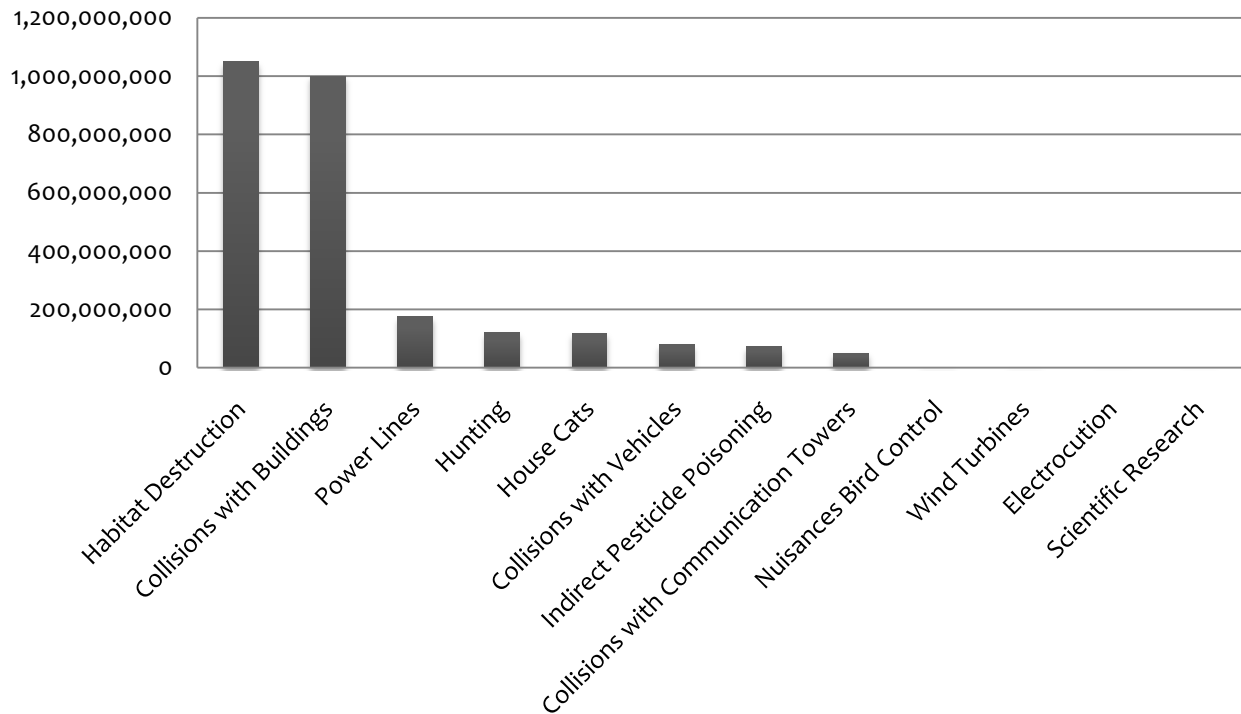


TABLE 2. INFORMATION INTERPRETED FROM FLAP.ORG

Habitat destruction and building collisions account for the majority of bird deaths in Canada and the United States per year (Table 1). Bird population decline is a consequence of both ground development and vertical development. Technological advances offer a myriad of benefits and growth opportunities for human populations. Yet, less attention to ecologically sensitive planning has been addressed at a 3-dimensional level. Though urban sprawl is still occurring, the issues associated with horizontal development are addressed at a more thorough level to help decrease negative impacts. When horizontal development is constrained by natural or artificial barriers, vertical development is often the only viable option. Vertical elements disrupting migratory avian species include tall buildings, power lines, wind turbines, and

communication towers. Though solar farms are not necessarily vertical obstructions physically, scorching temperatures above the fields and the reflective mirrors have been known to confuse and kill airborne wildlife disrupting entire food chains in the Nevada desert (Bigelow, 2014). Renewable resources at a large scale may not always be environmentally friendly.

Bird vision also may have an effect on their species survival. Birds have a fourth cone in their eyes allowing them to see the color spectrum human see as well as ultraviolet light (Cuthill, 2000). The ultraviolet light has shown potential importance in mate selection and foraging. For example, berries have a coating on them when they become ripe that reflects UV light attracting birds. Also, birds of prey can also track small mammals because their urine trails are reflective (Berger, 2012). Ultraviolet light could have a significant impact on wildlife conservation and urban design. Understanding materials birds are attracted to or discouraged from could also heavily impact design or material engineering.

If humans continue to develop the landscape without consideration of other species, hundreds of thousands of non-human species risk steeper population declines, endangered species status, or extinction unless humans begin to address the negative impacts we impose on them.

## CHAPTER 3: WHOOPING CRANE

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Birds are unique in the fact that they inhabit both the ground and the sky. They are a resilient species that are usually able to adapt to a fast changing world and are excellent indicators of ecosystem health. However, when the landscape changes too drastically too quickly, some species are not able to survive or are forced to relocate for resources. When human influences are the main cause for species decline, sometimes we need to intervene to reverse the negative impacts we have inflicted.

One avian species that has made a human-aided comeback from the brink of extinction is the whooping crane. As a species, the whooping crane tells an interesting story of survival and perseverance. This avian species was nearly extinct with a population of approximately 16 in the early 1940s, but has been slowly increasing with help from ultralight-led migration efforts from Wisconsin to Florida and stricter conservation laws. Some of the main reasons for the whooping cranes' former decline are loss of habitat due to construction of agricultural land, urban development, as well as hunting, pollution, and egg and specimen collecting.

Because of its needs for a specific ground-based habitat in a declining natural resource (wetlands), its relationship with humans in their population decline and increase, its unique migration habits, and geographical distribution, the whooping crane was chosen as a research subject. The crane travels across a greater distance than the size of local townships and other birds that inhabit one location year-round. The species allows us to connect a larger scale of landscape networks and natural resources available for wildlife and humans and identifies different landscape patterns.

The crane is a symbol of hope against environmental decline and also offers insight into best management planning practices. Though strong efforts have been taken to increase the whooping crane population, “cranes are constrained by their own biology, for they have evolved in tune with a life history strategy that favors long life and slow population growth, one that is fully at odds with the anthropogenic crises that they confront” (Hughes, 10). But unlike flightless wildlife, travel preparation and environmental conditions for migrating birds are much more extreme, making them a unique research subject. While our natural, undisturbed landscapes seem to be vanishing, the whooping crane provides an example of a determined species that defies extinction and performs alongside humans.

#### PHYSICAL ATTRIBUTES

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Whooping cranes are some of the largest species of birds standing at a height of approximately five feet tall. They are born brown. As they mature, they become white with black wing tips (Figure 9). Unfortunately, they were a popular hunting target before stricter conservation laws were enforced due to their size and beauty.



FIGURE 9. WHOOPING CRANES CARED FOR AND GUIDED BY OPERATION MIGRATION

(PHOTO GALLERY, 2013)

## HABITAT

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Historical fossil evidence indicates that whooping cranes resided largely over North America several million years ago, extending from central Canada to Mexico, and from Utah to the east Atlantic coast (Hughes, 241). Today, their numbers have dwindled to the endangered species category and their distribution has reduced to very select areas. Whooping cranes thrive naturally in wetland habitats. Nesting typically occurs in the middle of shallow waters, using this habitat as a protection mechanism. Being surrounded by water allows the cranes to hear approaching predators or creating splashing that may scare off predators. Being in the center of the water also provides resources for the cranes. Types of wetland/ wet habitats cranes utilize include: bulrushes, cattails, sedges, small ponds, marshes, muskeg, flooded prairie potholes, riparian marshes, reservoir margins, submerged sandbars, agricultural fields, wet meadows, savannas, brackish bays, salt flats, coastal marshes, and lake margins (Hughes, 241).

Whooping cranes have developed an adaptable diet that alters as they travel through North America. As the landscape pattern changes, their diets do as well. With more farmland present across the whooping cranes migration path, they have had to adjust to diets that do not necessarily provide the same resources wetlands have. Cranes are omnivores that consume waste grain in harvested agricultural fields, plant tubers, acorns, snails, small rodents, grasshoppers, aquatic insects, minnows, frogs, snakes, mollusks, crustaceans, and occasionally berries (Hughes, 241).

There are two migratory whooping crane flocks in North America; the western flock is a natural, self-sustaining flock (the only natural flock left in existence), the eastern flock is experimental with initial juvenile migration being led by humans. The western cranes nest in the

Canadian Territories at Wood Buffalo National Park and migrate over 2,500 miles to Aransas National Wildlife Refuge in Texas before the winter season (Figure 10). Eastern whooping cranes nest in central Wisconsin at Necedah National Wildlife Refuge and slowly migrate to Chassahowitzka National Wildlife Refuge in Florida with ultra-light aircraft and a team of scientists (Figure 10) (Hughes, 241).



FIGURE 10. WHOOPING CRANE MIGRATION POPULATIONS

## MIGRATION

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Over the last few decades, dedicated scientist have been breeding whooping cranes in captivity and then teaching the birds how to migrate to their Floridian habitat with an ultralight aircraft called a Trike (Figure 9). Birds are incredibly intelligent in multiple ways when it comes

to migration. Juvenile whooping cranes can be directed to the wintering site one time (by adult birds or humans) and return home to their summer habitat alone. In captivity, the birds are not able to migrate as naturally with the aircraft. During the human-aided migration, cranes travel shorter distances than they would in the wild, during different times of the day, and at different altitudes due to constraints of the aircraft and safety purposes for the cranes (Figure 11).

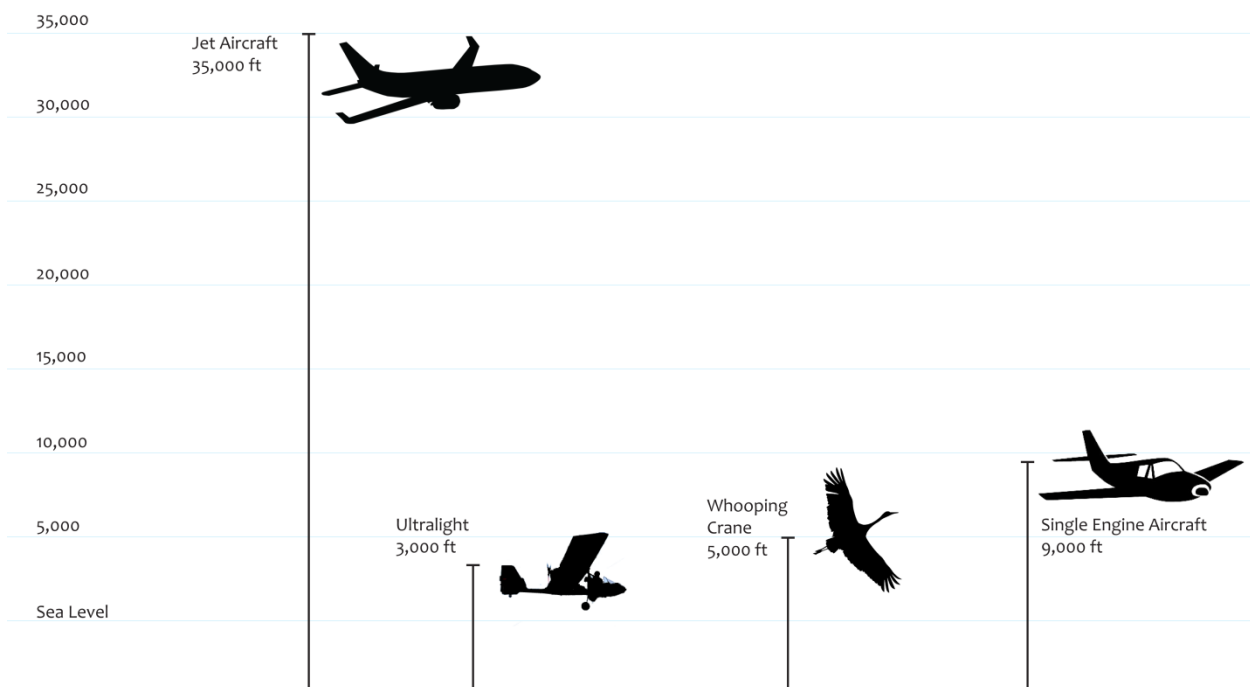


FIGURE 11. CRUISE ALTITUDES OF AIRBORNE TRAVELERS

When cranes travel with the aircraft, they usually migrate in the morning when the air is cooler and conditions are calm. The chances of the bird becoming injured from aircraft collision increases if the air becomes turbulent. However, thermals are a popular airborne resource many migratory birds utilize. Thermals are pockets of rising hot air that can cause turbulence and essentially feel like potholes in the sky. Whooping cranes typically wait later in the day to migrate when the earth becomes warmer and there are more thermals to ride.

Thermals help conserve energy and increase longevity of flight for the cranes. While thermals are beneficial to birds, they can be quite uncomfortable for humans. As for longevity of flight, cranes can fly between 200-300 miles at a time. Ultralights travel about 50-60 miles at a time with the birds. Thus, the trip with the aircraft takes about three months while the trip back for the cranes can average 7-14 days without the aircraft.

As a note, the human-aided comeback of the whooping crane does not imply that the cranes are domesticated. Scientists take very strict precautions during the breeding and migrating process to help them adjust to the natural environment as much as they can. Domestication or exposing the cranes to humans could become extremely dangerous to their survival. Some of the steps taken to disguise the human body include wearing white costumes with mock crane heads on one arm, humans are not to speak around the birds or become acclimated to human speech, avoiding vehicles and buildings during migration, and etc.

During migration with the ultralight aircraft, the cranes are usually penned in fields with an electric fence surrounding them for protection against predators. The aided migration does not provide many opportunities for these birds to rest at their natural wetland habitats along the way. Natural wetlands have been severely depleted due to competition with humans for agricultural resources and urban development. Land use analysis at the scale of flight and 3-dimensional perspective will identify vertical and horizontal threats to whooping crane and other wildlife conservation.



## CHAPTER 4: AVIATION

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Though land use and activities on the ground are extremely important, it is also important to recognize what is happening in the sky when acknowledging conservation efforts for migratory birds. Through flight, land use analysis is generalized, yet connectivity (or lack of connectivity) in the landscape is more apparent. Airborne networks have been strongly designed for human infrastructures, such as aviation, but habitat networks for wildlife are being reduced. Non-humans constantly have to find new outlets for resources and shelter as human populations have grown and development continues to spread outward and upward. The 3-dimensional land use analysis across thousands of miles in migratory bird pathways would not only benefit birds but also humans and the entire ecosystem's health. Aviation serves as a tool to help humans understand the 3-dimensional envelope of the world.

*“The airplane is the most visible of a great range of modern technologies that have progressively annihilated space by time over the course of this century... the boundaries that fragment terrestrial space disappear in flight, so that space is reduced to a network of points, intersecting lines and altitudinal planes. Connections between disparate places become easy, even routine, with the consequence that place distinctions seem to fade, nowhere more apparently than in locations associated with flight: in airports, hotels, or leisure resorts. The earth's topography flattens out to a canvas upon which the imagination can inscribe grandiose projects at an imperial scale”*

*-Taking Measures across the American Landscape (Corner, 4).*

### LAYERS

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Aeronautical sectional charts are maps pilots use to help navigate across the ground and through the sky (Figure 8 and Figure 13). Sectionals represent data in a 2-dimensional form and symbolize 3-dimensional components (Figure 12). For example, the circular rings symbolize

vertical airspaces and towers are listed with individual heights (Figure 8 and Figure 13). By visualizing the resources already available through aviation infrastructures, we can begin to create a 3-dimensional world in our land use analyses.

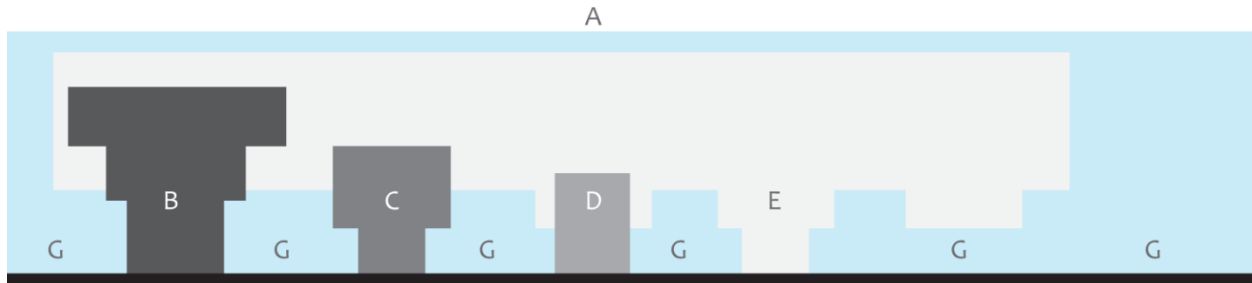


FIGURE 12. SECTION VIEW OF AIRSPACES A THROUGH G

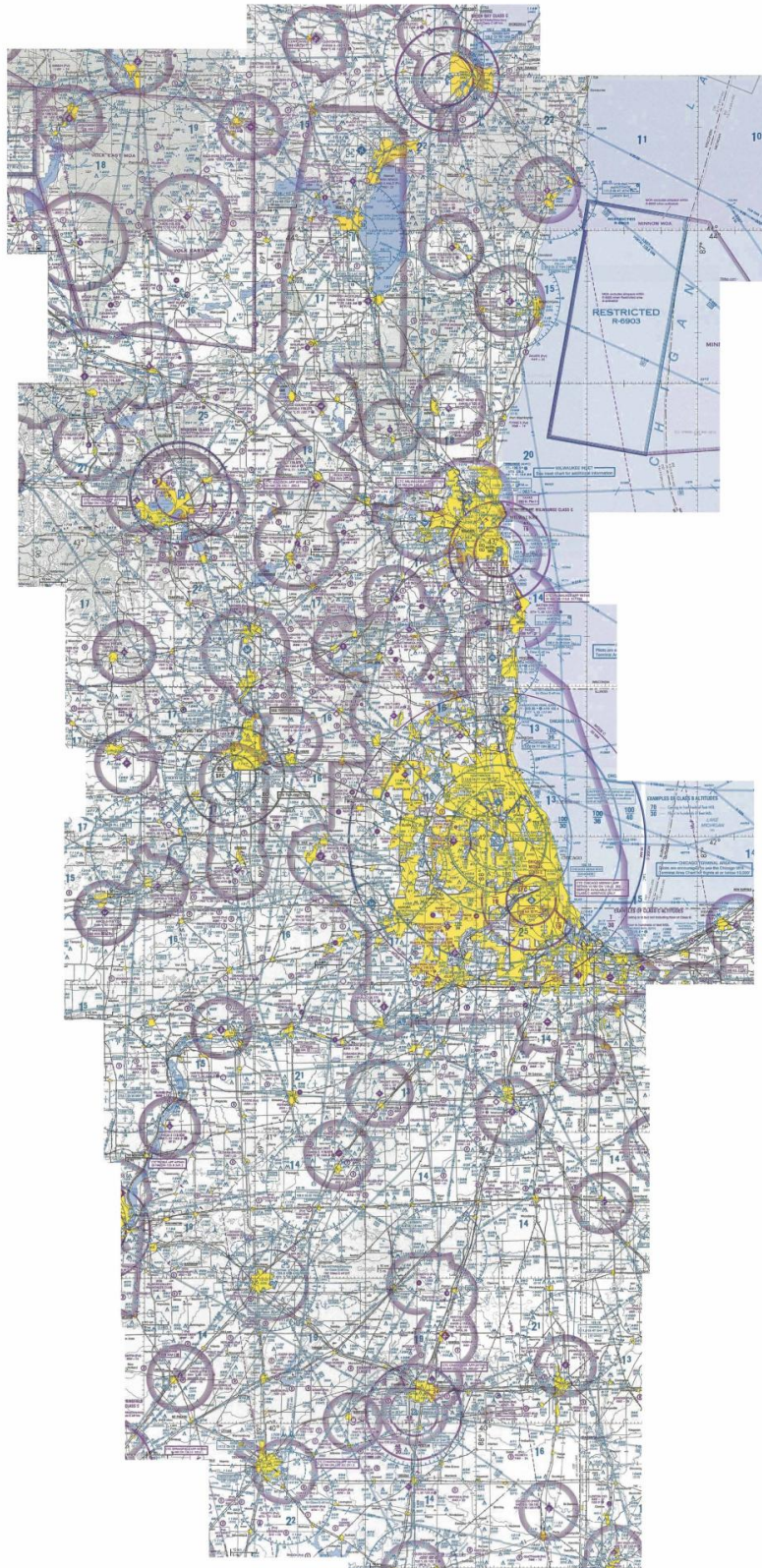


FIGURE 13. AERONAUTICAL SECTIONAL COMPILATION OVER THE SELECTED 300 MILE SITE



FIGURE 14. AERONAUTICAL INFORMATION DISSECTION OF THE RESEARCH SITE

Figure 14 illustrates generalized details compiled from the aeronautical charts in Figure 13. Many of the components is the dissection map displays the spatial distribution of vertical obstacles or boundaries over the Midwestern site. To explain, airspace, terrain, ground based obstacles, and control towered airports indicate a boundary for aviation. Towers for communication resources and wind farms are vertical structures that can become problematic in air travel.

Other than physical maps, pilots must also be able to interpret moving maps, like weather radar and weather codes called METARS. METARs are transmitted from a ground-based service station to an information system every hour of every day. METARs combine ground information with airborne information. The weather stations can detect how high precipitation develops (clouds) and how fast winds at different altitudes above the ground are moving. METAR information includes date, time of day, wind direction, wind speed, specific cloud cover type, altitude of cloud height, etc. (Figure 15).

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FIGURE 15. SAMPLE METAR

Ground-based navigational aids, called VORs, for aircraft are illustrated by dashed circles on the lower left of Figure 14. Humans are trained to operate a myriad of instruments to help them travel above the ground, but to migrate effectively, “birds need a sense of where they are, or need to be, a sense of direction, an ability to navigate from one place to another, and a sense of time, both seasonal and diurnal (essential for navigation by some celestial cues). In short, they need the equivalents of a map, compass, calendar and clock, together with a good memory, all packed into a brain that in some birds is no bigger than a pea” (Newton & Brockie, 232). Naturally birds

are provided with instinctual instruments to guide them to survival, but when our vertical technological or structural obstacles grow nature is not able to protect them as easily. Not only do birds need the ability to navigate naturally, but “birds also seem able to detect changes in barometric pressure, and to perceive wind direction and speed during flight, perhaps by reference to the ground below” (Newton, 227).

A dissected METAR example is provided in the upper left corner in Figures 16-18. This information can help us understand weather obstacles or the assistance weather provides for air travel. Ground travelers face less life-threatening situations than the varying atmospheric conditions (such as wind, cloud cover, thunderstorms, turbulence, and ice) birds and other creatures confront in the sky daily. Because atmospheric conditions continuously present variable circumstances for airborne travels, human aviation has a strong network of resources support routine operations and emergencies. With those resources already in place, it would be beneficial to expand the use of those resources to include consideration for flying wildlife.

As discussed in at the end of Chapter 2, renewable resource technologies like solar farms can alter atmospheric conditions unnaturally. Because humans are primarily a ground-based species, we do not always recognize our impacts on the atmosphere soon enough. However, our advancing technology is helping researchers and designers create a safer environment for all beings and to reduce negative impacts as effectively as possible. Weather and atmospheric data available through aviation can provide land use planners and designers better insight into what conditions at higher altitudes can produce.

## CHAPTER 5: DATA COLLECTION AND ANALYSIS

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### SPECIES SELECTION

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An avian species was chosen specifically due to its natural relationship with the ground and the sky. Through different species conservation websites, such as the Audubon Society and the Cornell Lab of Ornithology, I selected a bird based on geographical distribution and endangered species status. The whooping crane is an extremely endangered species located in a geographical region from Wisconsin to Florida that I have personally experienced for over 10 years. There are different sizes and categories of birds, but I specifically wanted to address migratory species to cover this area and a greater landscape scale. The natural landscape of this migratory path also has also been significantly altered by humans. Decline of the whooping crane is directly associated to human impacts on the species. The crane is also one of the few avian species that migrates with aircraft.

### HABITAT TYPE

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Wetlands are the primary habitat for whooping cranes. Crane decline is related to wetland decline. As described in Chapter 2, wetland percentages across the nation have quickly declined, with Illinois being just one of the states with original acreage loss over 90%. There are several different classifications of wetlands and information manuals on wetland types are readily available. Constructed wetlands are becoming more popular for today's restoration efforts. However, sometimes constructed wetlands serve different purposes, such as pollution control, which may provide less healthy habitats for wildlife than natural wetlands do. Wetlands, whether constructed or natural, provide countless benefits for the environment, but size and



location of wetlands have different roles for different species. An area with copious amounts of wetlands may actually be unsuitable for birds like the whooping crane or other wildlife because they lack some of the natural qualities essential for wildlife survival.

## AVIATION

To illustrate the different conditions in the sky, I recorded data in the air and on the ground to guide the audience through flight, as well as experience the phenomenon of flight (Figures 16-18). Atmospheric conditions are not always evident from the ground but have strong factors in the sky. What could appear to be a beautiful sunny day on the ground could be bumpy, hazy and low visibility conditions in the air. These atmospheric conditions can affect humans and birds differently.

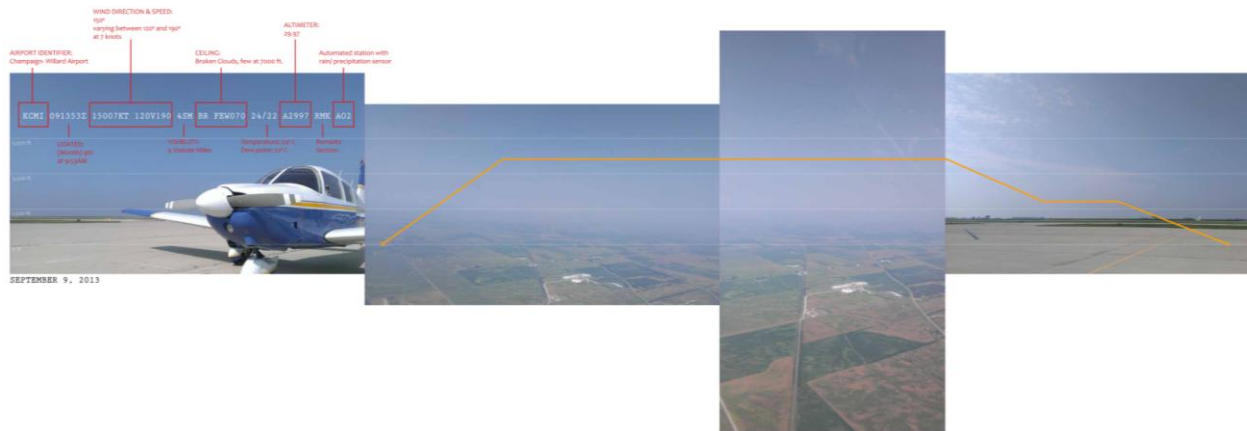


FIGURE 16. HOT AND HAZY ATMOSPHERIC CONDITIONS



FIGURE 17. COOLER AND CALM ATMOSPHERIC CONDITIONS WITH SCATTERED CLOUDS





FIGURE 18. CLEAR AND HOT CONDITIONS

Geographic Information Systems (GIS) orthoimagery quadrangle data can be found for most locations in the United States. Aerial imagery is readily available, but accessing landscape data on a vertical plane can be a challenge. By addressing the 3-dimensional landscape in land use planning, we can begin to connect the ground and the sky in land use analyses.

*“... Photography served as the primary means of recording our travels. Of course, in contrast to the motion of the traveler, the static nature of the photograph is unable to convey the temporal experiences of passage, the emerging and withdrawing of phenomena, and the strange ways events unfold. There is also a certain immediacy to the experience of a photograph, unlike the durational experience of narrative prose, movies, or soundtracks, for which sequential timing is essential. Nonetheless, the best photographs always entice and capture the imagination of the curious viewer, drawing him or her deep into the uniqueness of the moment”*

*-Taking Measures across the American Landscape (Corner, xv).*

Through GIS, I created a map of high quality aerial imagery in a transect of approximately 300 miles long for the Midwestern site (Figure 20). This view illustrates the pixilation of our developed landscape and how detached and modified “natural resources” have become. Though much time could be spent analyzing current human land use in this form, migratory birds are not completely benefited from this view of land use. We have representations 3-dimensional data for human aviation but lack the 3-dimensional details for other avian species

and vertical land use analysis. We should begin to combine data from aviation infrastructures with land use and wildlife resource to improve environmental health.

As humans, we have thoroughly defined our resource networks. If problems arise during flight, pilots have amply places to land for safety. When landings occur in an unplanned space, aircrafts are usually transported elsewhere for repair or more appropriate conditions. For example, if an emergency landing occurred in a corn field, an aircraft will usually be moved to the nearest hard surfaces or an airport. Figure 19 illustrates the connection of airports within the site boundaries, one of which is abundant throughout the area.

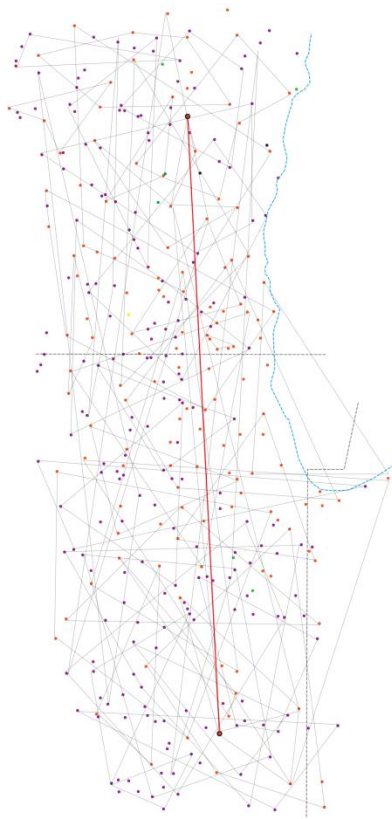


FIGURE 19. NETWORKS CONNECTING AIRPORTS THROUGHOUT ILLINOIS AND WISCONSIN

Wenche Dramstad in *Landscape Ecology Principles in Landscape Architecture and Land-use Planning* states that networks exhibit connectivity, circuitry, emphasize the functioning of landscapes, and may be used by planners and landscape architects to facilitate or inhibit flows and movements across a land mosaic (Dramstad, 41). Resource networks are available for humans but increasingly scarce for non-humans. With other biota having importance in sustaining a healthy ecosystem, networks for different non-humans species should become as connected as human networks.

## SCALE OF FLIGHT

To address different scales of flight, I explored different types of airborne travelers (Table 3). The crane exhibits impressive performance capabilities compared to our man-made mechanisms.

	WHOOPING CRANE	ULTRALIGHT	SINGLE ENGINE AIRCRAFT	JET AIRLINER
Wing Span	6.5 - 7.5 feet	32.5 feet	35.4 feet	108 feet
Body Length	49-56 inches	61 inches	24.7 feet	153 feet
Weight	14 - 17 lbs	420 lbs	3,000 lbs	191,000 - 210,000 lbs
Flight Speed	35-45 mph	25 - 45 mph	164 - 170 mph	570 - 605 mph
Distance Range	200 - 300 miles	50 - 60 miles	748 miles	1,500 - 2,000 miles
Ride on thermals?	yes	no	no	no
Follow landmarks?	no	yes	yes/ no	yes/ no

TABLE 3. WHOOPING CRANE AND AIRCRAFT COMPARISON CHART

Figure 20 displays high-quality aerial imagery over a 300 miles distance. The colorful transects identify the different paths of airborne travelers. The circular dots signify airspace, which are vertical boundaries for heavier aircraft traffic in the sky. Along these paths, the land use below constantly changes and is never the same. Yet, throughout the landscape pixilation is evident everywhere. Due to political boundaries and topography in certain regions, vertical and

green spaces alterations negatively or positively affect the non-human populations. Horizontal conservation is just as important as vertical mindfulness, but a 3-dimensional database could benefit airborne non-human travelers in our quickly developing world.

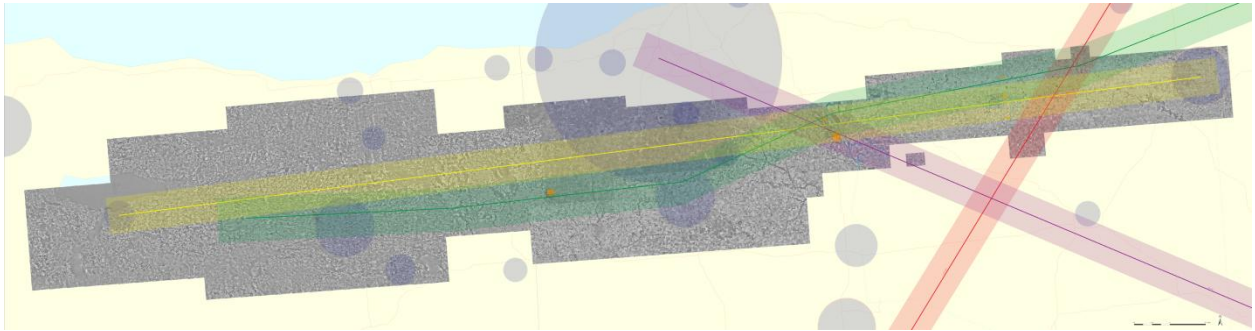


FIGURE 20. FLIGHT PATHS ALONG THE WISCONSIN AND ILLINOIS SITE

Land use analysis should become transformed into a 3-dimensional database combined with information provided by our aviation infrastructures. In additions, non-human species specific data, like the whooping crane, should begin to be considered in the definition of land use to support and create healthier ecosystems. Land use analysis at the scale of flight broadens insight for land use planning and helps identify pixilation and fragmentation in the landscape.

## CHAPTER 6: FINDINGS & SUGGESTIONS FOR FURTHER INVESTIGATION

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In today's increasingly influential anthropogenic world, land use should be considered for more than just for humans. Extensive urban and agricultural developments have been harmful to the whooping crane environment and other wildlife. Species, such as the whooping crane, have been resilient for tens of thousands of years. In the mid-1900s, the cranes almost became extinct due to human influences and are currently highly endangered. However, human efforts have also aided the whooping crane population to slowly increase. The whooping crane provides hope for the future and is a symbol of perseverance for ecological resilience.

With human population growth over the last few centuries and land scarcity approaching many countries, the desire to build upward is in higher demand. More attention needs to be given to airborne infrastructures during high-density or technological land use planning decisions. We need to understand vertical elements in the landscape if we will successfully develop our landscape sustainably. We do not need to train ecologists or urban planners to fly but take them through the sequence of flight and help them understand the limitations.

The landscape is a navigational tool that aides in air travel and weather is a phenomenon that determines the conditions one will experience while traveling the air. The goal is to help the audience understand what it takes to read a landscape through human technology and natural avian ability, and understand the obstacles of this invisible landscape. Aerial imagery is incredibly important, but aerial imagery in a dynamic, sequential movement can provoke greater insight in ecological design and land use management.

Bird vision and color could also play a major role in land use planning and urban design. Because birds are able to perceive ultraviolet light they interpret the landscape differently than humans. For example, windows and glass on buildings are also being reengineered to prevent bird collisions in some parts of the world. To a bird these new windows are designed to look like an obstructed barrier, but to the human eye the window appears to look transparent. In 2006, the German launched its UV-reflective product called Ornilux, reducing nearly 70% of bird collisions in laboratory tests (Chaisson, 2014). It has also been recognized that power lines emit strong discharges of ultraviolet light and can be disruptive to animal habitats for species that can see this spectrum of light (Zastrow, 2014). Creating new reflective materials or structural elements, such as changing the color of power line cables or tower beacon lighting colors, could potentially reduce airborne wildlife deaths by dissuasion or creating safer environments.

As humans, we have more control and influence over important resources. But in order to continue to support a healthy ecosystem and increase sustainability, we must monitor more closely the resources spanning over thousands of miles for our migratory non-human constituents as well. Flying aircraft is a skill set we as humans have to help us understand how birds function in flight. The landscape plays a crucial role in air travel and reaching the destination. In exploring the phenomenon of flight, a door may open for further use of the sky or may present even more limitations for development upward.

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